Heart-Healthy Fruit and Vegetable Consumption by Young Adults in Ohio

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Abstract

Cardiovascular disease (CVD) remains the leading cause of death across the United States. A single dietary change of increasing antioxidant-rich fruit and vegetable consumption can significantly decrease CVD risk. Thus in 2006, the American Heart Association (AHA) began promoting 8-10 daily servings of fruits and vegetables. The purpose of this secondary analysis of data from two parent studies was to determine if young adults in Central Ohio are meeting AHA fruit and vegetable recommendations and to describe associations between fruit and vegetable consumption, anthropometric measurements, education, and income. A socioeconomic model of health and its inequalities (Dahlgren & Whitehead) guided variable choices. Sample: Sixty healthy young adults from Central Ohio, ages 18-45 years. Methods: A descriptive, cross-sectional design was used to determine daily fruit and vegetable intake and evaluate relationships between variables. Lifestyle and food frequency questionnaires were completed by participants at The Ohio State University (OSU) Clinical Research Center (CRC). Anthropometric data were collected by CRC nurses. Results: The sample majority (87%) did not meet AHA fruit and vegetable recommendations. On average, participants consumed 2 servings (SD = 1.69) of fruit and 2 servings (SD = 2.45) of vegetables per day, which fall well below the minimum 8 daily servings advisement. A strong positive correlation emerged between vegetable consumption and income ($p = 0.05$). Furthermore, an average body mass index of 25.78 (SD = 5.89) classified the group as overweight, placing it at increased risk for several chronic diseases including CVD. Conclusions: Young adults in Central Ohio may not be consuming enough heart-healthy fruits and vegetables to lower their CVD risk. Developing strategies to promote AHA guidelines and identifying barriers to meeting the guidelines may improve long-term health in this population.

Keywords: fruits, vegetables, cardiovascular health

I. Introduction

Cardiovascular disease (CVD) is the most significant healthcare issue across the globe in terms of cost and lives affected. An estimated 17.3 million people died worldwide from CVD in 2008, representing 30% of all global deaths and ranking CVD as the number one cause of mortality (WHO, 2011). Furthermore, as the leading cause of mortality in both men and women in the U.S., CVD is linked to more than 2,200 daily deaths (Roger et al., 2011). It has been estimated that CVD leads to one U.S. death every 39 seconds. Among the 50 states and the District of Columbia, the state of Ohio ranks 14th in heart disease mortality rates (DeFiore-Hyrmer & Pryor, 2009). In 2003, there were more than 190,000 CVD-associated hospitalizations in Ohio, accounting for $4.8 billion in charges. Furthermore, in 2005, CVD was associated with 27% (28,995) of all Ohio deaths. If these dramatic trends continue, it is predicted that almost 23.6 million people worldwide will die from CVD by 2030 (WHO, 2011).

Although genetic factors play a significant role in the pathogenesis of CVD, there is a growing body of evidence that the effectiveness of lifestyle improvement strategies such as maintaining a healthy weight and choosing nutrient dense foods help prevent CVD (Lichtenstein et al., 2006). In spite of what is known about CVD prevention, however, the incidence and mortality rates continue to rise. Therefore, developing and disseminating innovative messaging strategies regarding CVD prevention should be major priorities for nurses and other healthcare professionals. One valuable lifestyle change that nurses can recommend to all patients, but especially to younger adults who may benefit the most from CVD prevention strategies, involves a cost-effective, non-pharmacological approach: choosing a healthier eating pattern. Importantly, a single dietary change of increasing antioxidant-rich fruits and vegetables has been linked to the prevention of CVD morbidity and mortality (Bazzano et al., 2002; Joshipura et al., 2001; Liu, Lee, et al., 2001; Liu, Manson, et al., 2000). Thus, the American Heart Association (AHA) began recommending 8-10 daily servings of fruits and vegetables in 2006 as a strategy to prevent CVD (Lichtenstein et al., 2006). On the global front, the World Health Organization (WHO) recently reported that inadequate consumption of fruits and vegetables is associated with up to 2.635 million deaths per year and that increasing individual intake to 600g/day could reduce the worldwide burden of CVD related morbidity and mortality by 31% (Lock, Pomerleau, Causer, Altmann, & McKee, 2005). The collective scientific evidence provides support for evaluating the impact that the AHA's fruit and vegetable advisements have on intake levels in the U.S., especially in population groups that could benefit the most from CVD prevention strategies.

Public health clinicians and policymakers often use socioeconomic models of health and its inequalities in the development of health promotion strategies to ensure that interventions support all subgroups of society and that care is directed in proportion to need ("Inequalities and Health," n.d.). A frequently used socioeconomic model of health inequalities is one developed by Dahlgren and Whitehead (1991). Their theoretical framework conceptualizes how a range of factors, or social determinants, can influence an individual's potential for health ("Inequalities and Health," n.d.). The individual is at the center of the model. Non-modifiable factors influencing health include age, gender, and genetic predisposition to disease. Modifiable determinants of health surround the individual and are depicted as a series of layers of influence; personal lifestyle factors (e.g. diet, physical activity, smoking, and alcohol or drug use); social and community factors (e.g. crime, social exclusion, and local cultural practices); environmental living and working conditions (e.g. housing and air or water sanitation); and general socioeconomic factors (e.g. poverty, income, and education). Thus, the Dahlgren and Whitehead (1991) model of health inequalities guided variable choices in the current study that could impact health (fruit and vegetable consumption, education, income, and anthropometric measures, which reflect diet and physical activity choices).

Although some studies have evaluated fruit and vegetable consumption patterns of the general U.S. population (Casagrande, Wang, Anderson, & Gary, 2007; Grimm et al., 2010; Guenther, Dodd, Reedy, & Krebs-Smith, 2006; Kimmons, Gillespie, Seymour, Serdula, & Blanck, 2009; Krebs-Smith, Cook, Subar, Cleveland, & Friday, 1995; Serdula et al., 1995; Subar et al., 1995; Thompson et al., 1999), the patterns of young adults who live in geographic locations known to have a higher prevalence of CVD morbidity and mortality, such as the state of Ohio, are unclear. Determining the average daily intake of fruits and vegetables and potential barriers to meeting the AHA recommendations in a sample of young adults in Ohio will generate new knowledge that can be used to inform the development of innovative strategies to encourage fruit and vegetable consumption in this population sector. Thus, the purpose of this secondary analysis of data from two parent studies was to compare the average daily servings of fruits and vegetables consumed by a sample of young adults in Central Ohio to the AHA recommended daily levels and to determine relationships between the number of daily servings of fruits and vegetables and key factors associated with CVD risk such as body mass index (BMI) and sagittal abdominal diameter (SAD), a measure of visceral obesity. In addition, based on the socioeconomic model of health and its inequalities by Dahlgren and Whitehead (1991), the relationships among fruit and vegetable intake, years of education completed, and income level were also explored.

II. Review of Literature

Literature searches were conducted in PubMed to identify original research studies and review articles relevant to the relationships among fruit and vegetable intake, CVD, and CVD risk. Studies that explored relationships among fruit and vegetable intake, BMI, SAD, education, and income were also identified. In this review of literature, applicable studies were grouped into five categories: fruit and vegetable consumption and CVD; fruit and vegetable consumption and CVD risk factors; fruit and vegetable consumption and BMI; fruit and vegetable consumption and education/income; and average fruit and vegetable consumption in the general U.S. population.

Fruit and Vegetable Consumption and CVD

The primary risk factors for CVD are dyslipidemia, hypertension, diabetes, and obesity, which are all linked to diets high in fat, sodium, sugar, and calories (Lichtenstein et al., 2006). Importantly, however, multiple studies have shown that dietary choices are modifiable and that consuming healthy foods contributes to optimal cardiovascular health (Appel et al., 1997; Appel et al., 2005; Knoops et al., 2004). Accordingly, key organizations focusing on CVD prevention, such as the AHA, began promoting healthy eating patterns as early as 1957. In 2006, the AHA proposed comprehensive dietary recommendations for the general public that emphasized whole-grains, high-fiber foods; oily fish; foods with little or no salt; and minimal foods with added sugar and saturated and trans fats (Lichtenstein et al., 2006). They also began recommending that Americans consume a diet rich in fruits and vegetables. Specifically, the AHA advises a total of 8-10 servings of fruits and vegetables per day. This advisement is based on the most current recommendations from the Dietary Guidelines for Americans released by the U.S. Departments of Health and Human Services and Agriculture (2005). The AHA (2011) defines a single serving as 1 medium fruit; ½ cup fresh, frozen, or canned fruit; ¼ cup dried fruit; ½ cup fruit juice; 1 cup raw leafy vegetable; ½ cup cut-up raw or cooked vegetable; or ½ cup vegetable juice. This recommendation is based on scientific evidence that most fruits and vegetables are high in fiber, potassium, folate, and antioxidant vitamins; nutritional components which have been associated with cardioprotective effects (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2005).

Several studies have examined the link between CVD risk and the consumption of fruits and vegetables as whole foods rather than the consumption of their individual nutritional components. In the Nurses' Health Study and the Health Professionals Follow-up Study, with 84,251 female participants aged 34-59 years and 42,148 males 40-75 years, Joshipura et al. (2001) found that, after adjusting for standard cardiovascular risk factors, persons in the highest quintile of fruit and vegetable intake (median: 5.8 servings per day among women and 5.1 servings per day among men) had a 20% lower risk for heart disease (multivariate relative risk, 0.80 [95% CI, 0.69 to 0.93]) than did those in the lowest quintile. They also reported that an intake greater than four servings per day appeared to decrease CVD risk and an intake of at least 8 servings per day produced an even greater risk reduction. Significantly, each one serving per day increase in participants' intake of fruits or vegetables was associated with a 4% lower risk for heart disease (relative risk, 0.96 [CI, 0.94 to 0.99]). The lowest risks were apparent in persons with high consumptions of green leafy vegetables, cruciferous vegetables, and vitamin C-rich fruits and vegetables.

Similar to the findings of the Nurses' Health Study and Health Professionals' Follow-Up Study (Joshipura et al., 2001), data from food-frequency questionnaires (FFQs) completed by participants in the Women's Health Study revealed a significant inverse association between fruit and vegetable intake and CVD risk (Liu, Manson, et al., 2000). The analysis of the information provided by 39,127 female health professionals showed that the median intake of total fruit and vegetables ranged from 2.6 servings per day in the lowest quintile to >10 servings per day in the highest quintile. After excluding participants with a self-reported history of diabetes, hypertension, hypercholesterolemia, and other high-risk conditions for CVD, the inverse association between consumption and CVD risk became even stronger. The age- and treatment-adjusted relative risk was 0.33 (95% CI, 0.17 to 0.64) and the multivariate-adjusted relative risk was 0.45 (95% CI, 0.22 to 0.91) when the two extreme quintiles were compared.

In another large, prospective cohort follow-up study of 15,220 middle-aged male physicians without a history of CVD or cancer, Liu, Lee, et al. (2001) also observed an inverse association between vegetable intake and risk of CVD. In multivariate models adjusted for age, treatment, history of diabetes, history of high cholesterol, history of hypertension, physical activity, BMI, cigarette smoking, alcohol intake, and use of multivitamins, the researchers found a relative risk for CVD of 0.83 (95% CI, 0.71 to 0.98) for each additional serving per day of vegetables consumed in this population segment.

Although the aforementioned studies report a significant correlation between increased fruit and vegetable consumption and CVD risk, they are not without limitations. As with many epidemiological studies of dietary patterns, misclassification is a concern because fruit and vegetable intake was self-reported through FFQs. However, FFQs have been found to have relatively high levels of reproducibility and validity as measures of average dietary intake over time (Feskanich et al., 1993; Rimm et al., 1992; Salvini et al., 1989; Willett et al., 1985). In addition, the study populations consisted of only healthcare professionals who may have different food habits and knowledge bases from those of the general population. While the relative homogeneity of education and occupation of the study participants added internal validity by minimizing the possibility that socioeconomic variables distorted findings, it remains unclear whether education and income have an influence on dietary choices (Liu, Lee, et al., 2001). Despite these limitations, the studies' large sample sizes and statistically significant findings provide evidence that fruit and vegetable consumption is associated with heart health.

In the interest of exploring the potential link between fruit and vegetable consumption and CVD in the general U.S. population, the first National Health and Nutrition Examination Survey Epidemiologic Follow-up Study (NHEFS) used a single 24-hour dietary recall and 3-month FFQs completed by a cross-sectional sample of 9,608 adults aged 25-74 years to assess usual fruit and vegetable consumption patterns (Bazzano et al., 2002). Sample participants consisted of an ongoing cohort from the first National Health and Nutrition Examination Survey (NHANES I), who were free of cardiovascular disease at the time of their baseline examination between 1971 and 1975. Over an average follow-up period of 19 years, consuming at least three or more servings of fruits and vegetables per day, compared with less than one serving per day, was associated with a 24% lower ischemic heart disease mortality (relative risk, 0.76 [95% CI, 0.56 to 1.03]), a 27% lower CVD mortality (0.73 [CI, 0.58 to 0.92]), and a 15% lower all-cause mortality (0.85 [CI, 0.72 to 1.00]) after adjustment for age, race, sex, history of diabetes, physical activity, education level, regular alcohol intake, current smoking, use of vitamin supplements, and total energy intake.

Although the NHEFS provides widely generalizable evidence of fruit and vegetable consumption benefits, self-report error is still a concern with FFQs and 24-hour dietary recall assessment measures (Bazzano et al., 2002). It is important to note, however, that it would be difficult to obtain enough participation and consent for a large long-term randomized, controlled trial of dietary patterns.

Collectively, the above study findings provide evidence that increased fruit and vegetable consumption has significant cardioprotective effects that would be particularly beneficial for young adults for whom CVD prevention is crucial. In addition, the findings provide scientific support for current national guidelines, such as those from the AHA, that promote increased intake of fruits and vegetables rather than individual nutrients to prevent CVD.

Fruit and Vegetable Consumption and CVD Risk Factors

Although the exact mechanisms of how fruits and vegetables allay the development of CVD are still being explored, several studies have linked increased fruit and vegetable intake to a lower incidence of hypertension, one of the most significant CVD risk factors. The Dietary Approaches to Stop Hypertension (DASH) randomized clinical trial tested the combined effects of nutrients within foods eaten as a whole on hypertension (Appel et al., 1997). DASH researchers fed 459 enrolled adults a control diet that was low in fruits, vegetables, and dairy products and contained a fat content typical of the average American diet for three weeks. Study participants were then randomly assigned to receive either the control diet, a diet rich in fruits and vegetables, or a combination diet rich in fruits, vegetables, and low-fat dairy products and with reduced saturated and total fat over an eight week period. The data revealed that a dietary pattern rich in fruits and vegetables significantly lowered blood pressure in adults both with and without hypertension. Similarly, a review by Dauchet, Amouyel, and Dallongeville (2009) reported that two additional clinical trials (Hypertension Prevention Trial Research Group, 1990; Margetts, Beilin, Vandongen, & Armstrong, 1986) and four observational population studies (Ascherio et al., 1992; Dauchet et al., 2007; Sacks, Rosner, & Kass, 1974; Shah et al., 1990) provided evidence that fruit and vegetable consumption aids in blood pressure regulation. Additionally, a randomized, controlled clinical trial in the U.K. found that 690 community-dwelling individuals aged 25-64 years who were encouraged to consume five daily portions of fruits and vegetables for six months had lower systolic and diastolic blood pressure values when compared to the control group (John, Ziebland, Yudkin, Roe, & Neil, 2002).

While a number of studies support the inverse relationship between fruit and vegetable consumption and hypertension, the review of literature findings by Dauchet, Amouyel, and Dallongeville (2009) suggested that the effects of fruit and vegetable intake on other CVD risk factors such as abnormal plasma lipid profiles, diabetes, and obesity are still unclear. Dauchet et al. (2009) reported inappropriate study designs, a lack of longitudinal study data, and inconsistent results across the studies reviewed. For example, some of the randomized prevention trials reviewed tested interventions involving a combination of fruit and vegetable intake promotion, physical activity, and weight loss on diabetes risk reduction. Therefore, the individual contribution of fruit and vegetables on diabetes risk was not definitive.

Conversely, in another review article, Lydia Bazzano (2006) reported growing – and promising – evidence for the benefits of fruit and vegetable intake on weight management and diabetes prevention. Fruits and vegetables are known to have low energy densities; and so, it has been hypothesized that replacing high energy-dense foods with fruits and vegetables can help to lower caloric intake and, thus, body weight. Bazzano referenced both a short- (5-day; Duncan, Bacon, & Weinsier, 1983) and long-term (3-week; Shintani, Hughes, Beckham, & O'Connor, 1991) study that confirmed this hypothesis. However, in addition to greater amounts of fruits and vegetables in the diet, she posits that little fat and increased whole grains in the diets may have been confounding factors contributing to participants' weight loss and reduced energy intake (Bazzano, 2006). Bazzano emphasized other important factors to consider regarding the study data she reviewed. For instance, the Nurses' Health Study demonstrated an inverse relationship between intake of vegetables and the development of diabetes, but no such association with fruits was reported (Colditz et al., 1992). Similarly, in the U.S. National Health and Nutrition Examination I Follow-Up Study, women who consumed five or more servings of fruits and vegetables per day were found to have a significantly lower incidence of diabetes than those who consumed none, but results were insignificant among men in the study (Ford & Mokdad, 2001).

An analysis of the current literature regarding fruit and vegetable intake in relation to CVD risk factors is crucial in determining whether there is a cause-and-effect relationship between increased fruit and vegetable consumption and CVD incidence. Thus it was meaningful to consider previous research before going forward with the current study. The majority of the collective findings suggest an association between increased consumption and reduced CVD risk factors, specifically reduced blood pressure; however, additional studies are needed to elucidate the link between fruit and vegetable intake and other CVD risk factors and to explore the mechanisms of CVD risk reduction.

Fruit and Vegetable Consumption and BMI

Obesity, defined by high BMI and high SAD, is linked to high blood cholesterol and triglyceride levels, low “good” HDL cholesterol, high fasting blood sugar, hypertension, and increased cardiac workload, factors which are associated with increased CVD risk (Poirier et al., 2006). Therefore, increasing fruit and vegetable consumption may reduce CVD risk by reducing BMI. A recent review of the literature to date provides a synthesis of the epidemiologic evidence available for the comparison of fruit and vegetable consumption and BMI or body weight (Tohill, Seymour, Serdula, Kettel-Khan, & Rolls, 2004). Tohill, Seymour, Serdula, Kettel-Khan, and Rolls (2004) found only one adult study that examined this issue as a primary objective. The majority of relevant studies reviewed evaluated the relationship between fruit and vegetable intake and disease; and so, only the bivariate association of fruit and vegetable intake with an anthropometric outcome was reported and available for review. Studies included in the review had varied methodologies, and very few adjusted for demographic, lifestyle, or other potential confounding factors. Tohill et al. (2004) concluded that although there was a tendency for higher body weight, and thus higher BMI, to be associated with lower fruit and vegetable consumption among adults in the examined studies, the evidence for this association remains insufficient. A number of studies reviewed reported a significant association between higher BMI categories and lower fruit and/or vegetable intake (Bazzano et al., 2002; Flood et al., 2002; Lin & Morrison, 2002; Rissanen et al., 2003), but others found no association (Laforge, Greene, & Prochaska, 1994; Liu, Lee, et al., 2001; Liu, Manson, et al., 2000; Patterson, B. H., Block, Rosenberger, Pee, & Kahle, 1990). Findings of higher weight linked to lower fruit and vegetable intake were also inconsistent among the genders (Lin & Morrison, 2002).

Thus, data from previous studies showing an association between fruit and vegetable consumption and BMI suggest that adding fruits and vegetables to the diet may result in a lower BMI, as this addition may replace foods with higher caloric and fat contents. Nevertheless, due to the small number of studies with this particular focus, further research is warranted to clarify the impact that fruit and vegetable consumption may have on BMI, or SAD, a more specific measure of abdominal obesity.

Fruit and Vegetable Consumption and Education/Income

Although rarely listed as a primary objective, several studies identified a link between frequency of fruit and vegetable consumption and sociodemographic data. Most recently, the 2009 Behavioral Risk Factor Surveillance System (BRFSS) found that the prevalence of consuming at least two servings of fruits and three servings of vegetables per day was greatest amongst college graduates and individuals with an annual household income of $50,000 or more

(Grimm et al., 2010). Similarly, higher income and greater education were significantly associated with compliance to the USDA-recommended 5-A-Day consumption pattern examined in the NHANES III and NHANES 1999-2002 (Casagrande, Wang, Anderson, & Gary, 2007). At least five additional studies have also reported a positive association between educational attainment and/or income level with increased fruit and vegetable consumption (Kimmons, Gillespie, Seymour, Serdula, & Blanck, 2009; Miura, Giskes, & Turrell, 2011; Serdula et al., 1995; Subar et al., 1995; Thompson et al., 1999).

The overwhelming evidence suggests that educational and economic disparities are affecting fruit and vegetable intake. Regular consumption of inexpensive and convenient, yet less healthy, take-out foods may be displacing fruit and vegetables in the diet (Miura, Giskes, & Turrell, 2011). Limited access to fresh food, limited dietary health awareness, and the high cost of fruits and vegetables may also be contributing to lower intake. Thus, national messages to increase fruit and vegetable intake may be ineffective in producing behavioral change in certain population segments, such as those with a low socioeconomic status. These findings are disconcerting because education and income levels have also been inversely associated with heart disease rates in U.S. adults (Schiller, Lucas, Ward, & Peregoy, 2012). Therefore, additional research is needed to inform the development of more effective, multifaceted approaches to change fruit and vegetable intake patterns in vulnerable populations.

Average Fruit and Vegetable Consumption in the General U.S. Population

While the cardiovascular benefits of consuming a diet rich in fruits and vegetables are scientifically based, the majority of Americans, regardless of sociodemographic factors, eat far fewer daily servings than recommended. Numerous studies have reported the consistent under-consumption of recommended fruit and vegetable intake by American adults from the late 1980s through today (Casagrande, Wang, Anderson, & Gary, 2007; Grimm et al., 2010; Guenther, Dodd, Reedy, & Krebs-Smith, 2006; Kimmons, Gillespie, Seymour, Serdula, & Blanck, 2009; Krebs-Smith, Cook, Subar, Cleveland, & Friday, 1995; Serdula et al., 1995; Subar et al., 1995; Thompson et al., 1999). For example, Guenther, Dodd, Reedy, and Krebs-Smith (2006) found that in 1999-2000 only 40% of the U.S. population met the then-current USDA recommendation of five or more servings of fruits and vegetables per day – a mere 8% increase in compliant American adults from the USDA's 1989-1991 findings in the Continuing Surveys of Food Intakes by Individuals (CSFII; Krebs-Smith et al., 1995). Compared to the previously reported mean intake of 4.3 servings per day (Krebs-Smith et al., 1995), Guenther et al. (2006) estimated the population's mean intake of fruits and vegetables to be marginally higher at 4.7 ± 0.1 servings per day at that time. Mean intakes by all sex-age groups were below the recommended values for fruits, total vegetables, and all subgroups of vegetables with one exception: starchy vegetables (mainly white potatoes, corn, and peas).

This trend of under-consumption of fruits and vegetables in the U.S. has become more pronounced over the years. Using 24-hour dietary recall data from similar sample sizes in a similar time period, researchers analyzing the NHANES III (1988-1994) and NHANES 1999-2002 estimated that a lower percentage of adults met the USDA's vegetable ($\geq$ 3 servings per day) guidelines from 1999-2002 compared to 1988-1994 (Casagrande, Wang, Anderson, & Gary, 2007). Furthermore, only 11% met the guidelines for both fruit and vegetable intake ($\geq$ 5 servings per day) from 1988-1994 and 1999-2002, indicating no change in consumption patterns despite the initiation of the national “5-A-Day” fruit and vegetable campaign in 1991. Furthermore, the results of a random-digit dialing telephone survey of 23,699 adults from 16 U.S. states in 1990 indicated lower consumption rates than previously reported data (Serdula et al., 1995). The data revealed that only 20% of the study population consumed the recommended five or more daily servings. Additionally, an analysis of 24-hour recall data from the 2003-2004 NHANES found that less than 1 in 10 Americans met their calorie-specific MyPyramid fruit or vegetable recommendations (Kimmons, Gillespie, Seymour, Serdula, & Blanck, 2009).

More recently, using the now-outdated 5-A-Day guidelines, the Centers for Disease Control (CDC) compiled data from 420,968 Americans, representing all 50 states and the District of Columbia (Grimm et al., 2010). These data showed that in 2009, an estimated 32.5% of adults consumed fruit two or more times per day and 26.3% consumed vegetables three or more times per day. According to the CDC, these statistics fall far short of the national targets outlined in *Healthy People 2010*, which aim to increase the proportion of persons who follow the 5-A-Day recommendation. Importantly, the CDC revealed that no state met the fruit and vegetable 5-A-Day targets and considerable variability occurred among states. The collective findings suggest that the general U.S. population is under-consuming fruits and vegetables. Moreover, studies continue to reference the USDA's 5-A-Day guideline, which is not aligned with the current minimum AHA intake recommendation of eight combined servings of fruits and vegetables per day. Thus, future research should not only focus on individual states, but also consider the most current fruit and vegetable endorsements for heart health from the AHA.

Conclusion

The majority of studies presented in this review of literature demonstrate the significant cardiovascular benefits to increasing fruit and vegetable consumption to meet AHA guidelines. While the exact mechanisms of how fruits and vegetables prevent CVD remain unclear, studies suggest that nutrient-rich fruits and vegetables may inhibit the development of known CVD risk factors such as hypertension and high BMI. However, research has identified lower levels of education and income as potential barriers to choosing a diet rich in fruits and vegetables. Although some studies have shown that the general U.S. population is not meeting national guideline recommendations for fruit and vegetable intake, it is unknown whether specific population segments, such as young adults in areas with high prevalence rates for CVD, are following the most current AHA guidelines for a heart-healthy diet. Therefore, this study's goal was to compare the estimated daily servings of fruits and vegetables consumed by young adults in Central Ohio to the AHA guidelines and explore the relationships among fruit and vegetable intake, BMI, SAD, years of education, and income level.

III. Methods

This study is a secondary analysis of data derived from two randomized, double-blind, prospective trials (McDaniel, Belury, Ahijevych, & Blakely, 2008; McDaniel, Massey, & Nicolaou, 2011) conducted at The Ohio State University Clinical Research Center (CRC). The current study evaluated sociodemographic, nutritional, and body composition data collected at baseline in the parent studies to answer the research questions: (1) Are young adults in a Central Ohio community consuming the AHA's recommended servings of fruits and vegetables for CVD prevention? (2) Are the daily servings of fruits and vegetables consumed by the young adult sample associated with anthropometric measures (BMI, SAD), education, and income?

We hypothesized that young adults in Central Ohio are consuming less than the AHA's recommended daily servings of fruits and vegetables and that higher BMI, higher SAD, lower educational level, and lower economic status would be associated with fewer daily servings of fruits and vegetables.

Theoretical Framework

The socioeconomic model of health and its inequalities by Dahlgren and Whitehead

(1991) guided the choice of variables: fruit and vegetable intake, anthropometric measures, education, and income. This model was designed to explore the associations among certain physiological and socioeconomic factors that could impact behavioral determinants of health, such as choosing to eat adequate servings of fruits and vegetables on a daily basis.

Design

This retrospective, secondary analysis used a descriptive, cross-sectional design to answer the research questions.

Participants

Data from a total of 60 healthy young adults, ages 18-45 years, from Central Ohio were included in this analysis. Complete data were obtained from forty participants (20 men and 20 women) in the first parent study (McDaniel, Belury, Ahijevych, & Blakely, 2008) and from 20 participants (10 men and 10 women) in the second study (McDaniel, Massey, & Nicolaou, 2011). Inclusion criteria included healthy adults between 18 and 45 years of age. Exclusion criteria included vitamin, mineral, or other nutritional supplement or medication use within three months of study entry. Individuals with a history of health problems such as cancer, autoimmune diseases, diabetes mellitus or peripheral vascular disease, difficulties with wound healing, surgery in the past year, self-reported current smokers, or those reporting drinking 10 or more alcoholic beverages per week were also excluded. Participants were recruited from an academic area by placing advertisements in The Ohio State University's newspaper and posting flyers in several of the individual colleges. The parent studies were approved by an Institutional Review Board and conducted in accordance with the ethical rules for human experimentation stated in the 1975 Declaration of Helsinki.

Sample Size Justification

Before conducting the study, a power analysis determined that 85 subjects would be necessary to obtain 80% power to detect a correlation of 0.266 at an alpha level of 0.05 among fruit and vegetable intake, body composition, education, and income. Since there were data from only 60 subjects, the power to detect a correlation of 0.266 at an alpha level of 0.05 was reduced to 67%.

Protocol

In the two parent studies (McDaniel, Belury, Ahijevych, & Blakely, 2008; McDaniel, Massey, & Nicolaou, 2011), young adults who met the inclusion/exclusion criteria participated in a 25-hour protocol at The Ohio State University Clinical Research Center (CRC). Both parent studies were prospective, randomized trials designed to test the efficacy of a nutritional supplement on acute blister wound healing. On arrival, anthropometric measures were taken and recorded by the CRC bionutritionists. During this time, all study participants completed one questionnaire that elicited sociodemographic data including education and income levels. In addition, electronic FFQs were completed by all study participants that generated nutritional data. The VioFFQ software (Viocare Technologies, Inc.) used is designed to obtain information about micro and macro nutrient intake during the three months prior to completing the questionnaire. Data from the FFQs allowed for comparisons of nutrients important for efficient wound healing between groups at baseline in the parent studies. Additional protocol details have been described previously (McDaniel, Belury, et al., 2008; McDaniel, Massey, et al., 2011).

Instruments

Anthropometric Data. Height, weight, BMI, and SAD were calculated. Height was measured using the Harpendon Stadiometer (Holtain Limited, Crymych, Dyfed, U.K.) to the nearest 0.1 cm. Body weight was measured using the ProPlus Scale (Healthometer, Bridgeview Illinois) to the nearest 0.1 kg. BMI was calculated as body weight (kg) divided by height (m) squared. SAD, the distance from the back to the upper abdomen at the point midway between the top of the pelvis and the bottom of the ribs while supine, was measured to the nearest 0.1 cm using the Holtain-Kahn Abdominal Caliper (Holtain Limited, Crymych, Dyfed, U.K.).

Education and Income. Participants completed a health and lifestyle questionnaire wherein they self-reported gender, age, race, years of education (less than 7 years, junior high school, some high school, high school, some college, college or university graduate [Bachelors or equivalent], and graduate or professional training [Masters, JD, MD, PhD, etc.]), and income level ($0 to 4,999; $5,000 to 9,999; $10,000 to 14,999; $15,000 to 19,999; $20,000 to 24,999; $25,000 to 29,999; $30,000 to 34,999; $35,000 to 39,999; $40,000 to 44,999; and $45,000 and up).

Fruit and Vegetable Intake. The VioFFQ software tool (Viocare Technologies, Inc.) was used to estimate food choices such as fruit and vegetable intake in the previous 90 days. It is based on the FFQ used and validated for the Women's Health Initiative (Patterson, R. E., et al., 1999). This web-based system allows subjects to self-administer the FFQ from a tablet computer connected to the Internet. Participants received five minutes of audio and visual instruction before completing the FFQ, which takes approximately 30 minutes to complete and asks questions about the type, frequency, and quantity of foods and beverages consumed in the past 90 days. The bionutritionists at the CRC were available to assist participants as needed. The data generated included a nutrient analysis of macro and micro nutrients consumed on a per day basis, food patterning, and an educational report for the study participants. The dietary analysis was completed by the CRC bionutritionists and utilized food and nutrient information from the

Nutrition Coordinating Center (NCC) Food and Nutrient Database developed and maintained by the NCC, located at the University of Minnesota Division of Epidemiology and Community Health in Minneapolis.

Data Analysis

Descriptive statistics, including percent, range, mean, and standard deviation (SD), were used to characterize sociodemographic, nutritional, and body composition data. Statistical analysis was performed using a series of regression and ANOVA models. In all models, servings of fruit and servings of vegetables were found to be right-skewed, so these variables were transformed to the natural log scale before performing statistical analysis. ANOVA models were used to examine the relationship between education level and intake of fruit and vegetables as well as the relationships between gender and race and intake of fruit and vegetables. Separate regression models were fit to examine the relationship between income level and intake of fruit and vegetables along with the relationship between age and intake of fruit and vegetables. Finally, regression models were used to examine the relationship between BMI and intake of fruit and vegetables.

IV. Results

Participant Characteristics

This secondary analysis compiled data on 60 young adults, ages 18-45 years, from Central Ohio who had no history of chronic disease and were not presently taking prescription medications, vitamins, or minerals. In this sample, half of the participants were male and the majority was Caucasian (Table 1). The mean age was 25.5 years. The participants had an average BMI of 25.8 and an average SAD of 19.2 cm. The vast majority of participants had over 12 years of education, with 41.9% having had some college education and 40.3% college or university graduates. Income levels varied, as 31.7% self-reported earnings less than $10,000 annually while 28.3% self-reported in the highest quartile, with an annual income of more than $45,000. The VioFFQ (Viocare Technologies, Inc.) indicated an average fruit intake of 2.04 servings/day and an average vegetable intake of 2.15 servings/day among participants. Average fruit and vegetable intake combined ranged from 0.5 to 21 servings/day, with an average combined intake of 4.19 servings/day.

Table 1 *Demographic and Consumption Characteristics of Sample (n=60)*

	Mean ± SD / %	Range
Age (years)	25.52 ± 6.33	18 – 45
Body Mass Index (kg/m^2)	25.78 ± 5.89	17.70 – 47.18
Sagittal Abdominal Diameter (cm)	19.16 ± 3.56	13.70 – 33.90
Men (%)	50.0	
Race (%) Non-Hispanic White Non-Hispanic Black Asian Other	 81.4 5.1 11.9 1.6	 -
Education (%) 12 years > 12 years	 1.7 98.3	 -
Income (%) < $10,000 $10,000 - $24,999 $25,000 - $44,999 > $45,000	 33.3 19.4 17.5 29.8	 -
Fruit Intake (daily servings)	2.04 ± 1.69	0.05 – 9.18
Vegetable Intake (daily servings)	2.15 ± 2.45	0.16 – 14.17
Fruit and Vegetable Intake Combined (daily servings)	4.19 ± 3.47	0.48 – 20.77

Fruit and Vegetable Consumption and Gender

ANOVA models were used to examine the relationship between the subjects' gender and intake of fruits and vegetables. Results indicated that gender was not significantly associated with servings of fruit, servings of vegetables, or total servings of fruit and vegetables combined (Table 2).

Table 2 *Relationship between Gender and Fruit and Vegetable Intake (n=60)*

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Logfruit	Between Groups	1.148	1	1.148	1.383	.244
	Within Groups	48.150	58	.830		
	Total	49.299	59			
Logveg	Between Groups	.067	1	.067	.091	.764
	Within Groups	42.550	58	.734		
	Total	42.617	59			
Logsumfrtveg	Between Groups	.279	1	.279	.540	.466
	Within Groups	29.980	58	.517		
	Total	30.259	59			

ONEWAY Logfruit Logveg Logsumfrtveg BY Gender

Fruit and Vegetable Consumption and Race

ANOVA models were used to examine the relationship between the subjects' race and intake of fruits and vegetables. One race category contained only one respondent, so that respondent was removed from the analysis. The remaining participants comprised three races: Non-Hispanic White, Non-Hispanic Black, and Asian. Results showed that race was not significantly associated with servings of fruit, servings of vegetables, or total servings of fruit and vegetables (Table 3).

Table 3 *Relationship between Race and Fruit and Vegetable Intake (n=60)*

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Logfruit	Between Groups	4.441	3	1.480	1.820	.154
	Within Groups	44.723	55	.813		
	Total	49.163	58			
Logveg	Between Groups	3.321	3	1.107	1.567	.208
	Within Groups	38.862	55	.707		
	Total	42.183	58			
Logsumfrtveg	Between Groups	3.586	3	1.195	2.500	.069
	Within Groups	26.299	55	.478		
	Total	29.885	58			

ONEWAY Logfruit Logveg Logsumfrtveg BY Race

Fruit and Vegetable Consumption and Age

Separate regression models were fit to examine whether the subjects' age was associated with intake of fruits and vegetables. Results indicated that age was not significantly associated with the number of servings of vegetables (Table 4). However, age was found to be marginally significantly associated with the number of servings of fruits ($p = 0.090$; Table 5) and significantly associated with total servings of fruits and vegetables combined ($p = 0.053$; Table 6). An increase of one year of age was found to be associated with an average increase of 3.25% in daily servings of fruit and an average increase of 2.94% in daily servings of total fruits and vegetables combined.

Table 4 *Relationship between Age and Vegetable Intake (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.991	1	.991	1.381	.245[a]
	Residual	41.626	58	.718		
	Total	42.617	59			

a. Predictors: (Constant), Age

b. Dependent Variable: Logveg

Table 5 *Relationship between Age and Fruit Intake (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.403	1	2.403	2.972	.090[a]
	Residual	46.896	58	.809		
	Total	49.299	59			

a. Predictors: (Constant), Age

b. Dependent Variable: Logfruit

Table 6 *Relationship between Age and Fruit and Vegetable Intake Combined (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.906	1	1.906	3.898	.053[a]
	Residual	28.354	58	.489		
	Total	30.259	59			

a. Predictors: (Constant), Age

b. Dependent Variable: Logsumfrtveg

Fruit and Vegetable Consumption and Anthropometric Measures

Regression models were used to examine whether the subjects' BMI or SAD were associated with intake of fruit and vegetables. BMI was found to be right-skewed, so it was transformed to the natural log scale before modeling. No significant relationship was detected between fruit servings (Table 7), vegetable servings (Table 8), or total servings of fruit and vegetables combined and BMI (Table 9). As with BMI, SAD was found to be right-skewed so it was transformed to the natural log scale before modeling. No significant relationship was detected between fruit servings (Table 10), vegetable servings (Table 11), or total servings of fruit and vegetables combine and SAD (Table 12).

Table 7 *Relationship between BMI and Fruit Intake (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.048	1	.048	1.120	.294[a]
	Residual	2.508	58	.043		
	Total	2.556	59			

a. Predictors: (Constant), Logfruit

b. Dependent Variable: LogBMI

Table 8 *Relationship between BMI and Vegetable Intake (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.059	1	.059	1.361	.248[a]
	Residual	2.497	58	.043		
	Total	2.556	59			

a. Predictors: (Constant), Logveg

b. Dependent Variable: LogBMI

Table 9 *Relationship between BMI and Fruit and Vegetable Intake Combined (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.115	1	.115	2.739	.103[a]
	Residual	2.441	58	.042		
	Total	2.556	59			

a. Predictors: (Constant), Logsumfrtveg

b. Dependent Variable: LogBMI

Table 10 *Relationship between SAD and Fruit Intake (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.002	1	.002	.074	.786[a]
	Residual	1.691	58	.029		
	Total	1.693	59			

a. Predictors: (Constant), Logfruit

b. Dependent Variable: LogSAD

Table 11 *Relationship between SAD and Vegetable Intake (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.026	1	.026	.914	.343[a]
	Residual	1.667	58	.029		
	Total	1.693	59			

a. Predictors: (Constant), Logveg

b. Dependent Variable: LogSAD

Table 12 *Relationship between SAD and Fruit and Vegetable Intake Combined (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.034	1	.034	1.183	.281[a]
	Residual	1.659	58	.029		
	Total	1.693	59			

a. Predictors: (Constant), Logsumfrtveg

b. Dependent Variable: LogSAD

Fruit and Vegetable Consumption and Education

ANOVA models were used to examine the relationship between the subjects' education level and intake of fruits and vegetables. Results indicated that education level was not significantly associated with servings of fruit, servings of vegetables, or total servings of fruit and vegetables combined (Table 13).

Table 13 *Relationship between Education and Fruit and Vegetable Intake (n=60)*

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Logfruit	Between Groups	.024	3	.008	.009	.999
	Within Groups	48.770	54	.903		
	Total	48.794	57			
Logveg	Between Groups	1.243	3	.414	.554	.648
	Within Groups	40.396	54	.748		
	Total	41.639	57			
Logsumfrtveg	Between Groups	.367	3	.122	.229	.876
	Within Groups	28.909	54	.535		
	Total	29.277	57			

ONEWAY Logfruit Logveg Logsumfrtveg BY Education

Fruit and Vegetable Consumption and Income

Separate regression models were fit to examine whether the subjects' income was associated with intake of fruits and vegetables. Results showed that income level was not significantly associated with daily servings of fruit (Table 14) or total servings of fruit and vegetables (Table 15). However, income level was significantly associated with daily servings of vegetables ($p = 0.016$; Table 16). A one-category increase in income level was found to be associated with an average increase of 7.79% in daily servings of vegetables.

Table 14 *Relationship between Income and Fruit Intake (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.059	1	.059	.068	.796[a]
	Residual	48.735	56	.870		
	Total	48.794	57			

a. Predictors: (Constant), Income

b. Dependent Variable: Logfruit

Table 15 *Relationship between Income and Fruit and Vegetable Intake Combined (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.042	1	1.042	2.067	.156[a]
	Residual	28.234	56	.504		
	Total	29.277	57			

a. Predictors: (Constant), Income

b. Dependent Variable: Logsumfrtveg

Table 16 *Relationship between Income and Vegetable Intake (n=60)*

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.161	1	4.161	6.218	.016[a]
	Residual	37.478	56	.669		
	Total	41.639	57			

a. Predictors: (Constant), Income

b. Dependent Variable: Logveg

V. Discussion

The most significant finding of this study is that, as hypothesized, the majority (87%) of the young adult sample did not meet the AHA's consumption recommendations for CVD prevention. On average, the group consumed only four servings of fruits and vegetables each day, which is well below the minimum of eight daily servings recommended by the AHA. This pattern of under-consumption is consistent with previous studies reporting inadequate fruit and vegetable intake by adults of all ages across the U.S. as a whole (Casagrande, Wang, Anderson, & Gary, 2007; Grimm et al., 2010; Guenther, Dodd, Reedy, & Krebs-Smith, 2006; Kimmons, Gillespie, Seymour, Serdula, & Blanck, 2009; Krebs-Smith, Cook, Subar, Cleveland, & Friday, 1995; Serdula et al., 1995; Subar et al., 1995; Thompson et al., 1999). The current study findings support previous suggestions that the heart-healthy recommendations from the AHA are largely unheeded and new, more effective messaging campaigns are needed.

In this study, relationships between fruit and vegetable intake and sociodemographic factors were evaluated to help identify potential barriers to consuming adequate fruits and vegetables in the young adult sector. An important finding that emerged is that income level was found to be significantly associated with daily servings of vegetables (p = 0.016). This data suggests that those with greater financial resources are more likely to purchase and consume heart-healthy vegetables than those with lower incomes, which is a finding that is aligned with several previous studies reporting a significant positive relationship between income and fruit and vegetable consumption (Casagrande, Wang, Anderson, & Gary, 2007; Grimm et al., 2010; Subar et al., 1995). Interestingly, however, educational level was not significantly associated with daily fruit and vegetable servings in the current study. This finding does not support our hypothesis that those with more years of education consume more fruits and vegetables on a daily basis than those with less education. In addition, our findings are not aligned with several previous studies noting positive correlations between these two variables (Casagrande et al., 2007; Grimm et al., 2010; Kimmons, Gillespie, Seymour, Serdula, & Blanck, 2009; Miura, Giskes, & Turrell, 2011; Serdula et al., 1995; Subar et al., 1995; Thompson et al., 1999). Nevertheless, these study findings suggest that a young adult with a higher level of education may not be more knowledgeable of nutritional health than a young adult with a lower level of education. Thus, interventions designed to disseminate the important messages regarding fruit and vegetable consumption should target all young adults regardless of educational status.

Other sociodemographic characteristics that were evaluated in the current study included gender, race, and age. No significant relationship was found between gender or race and fruit and vegetable consumption. These findings are not aligned with previous study reports of gender and racial disparities regarding fruit and vegetable intake (Casagrande, Wang, Anderson, & Gary, 2007; Grimm et al., 2010; Kimmons, Gillespie, Seymour, Serdula, & Blanck, 2009; Serdula et al., 1995; Subar et al., 1995; Thompson et al., 1999). Although neither gender nor race predicted consumption patterns in the current study, age was found to be marginally significantly associated with the number of servings of fruits ($p = 0.090$) and significantly associated with total servings of fruits and vegetables combined ($p = 0.053$). This data implies that even within the young adult age group (18-45 years) as one ages, consuming a healthy diet becomes more important. Furthermore, this finding is comparable to similar studies that have noted increased fruit and vegetable consumption with advancing age (Casagrande et al., 2007; Grimm et al., 2010; Kimmons et al., 2009; Serdula et al., 1995; Subar et al., 1995). For example, Grimm et al. (2010) reported that in 2009 the greatest prevalence of consuming fruit two or more times per day or vegetables three or more times per day was observed in a large representative sample of U.S. adults aged 65 or older. The collective findings of the current study regarding sociodemographic characteristics suggest that dietary initiatives to increase fruit and vegetable intake should target all younger adults, regardless of gender, race, income or education level.

In addition to sociodemographic characteristics, anthropometric measures (BMI and SAD) were evaluated in the current study because several previous studies have reported an inverse relationship between BMI and fruit and vegetable consumption (Bazzano et al., 2002; Flood et al., 2002; Lin & Morrison, 2002; Rissanen et al., 2003). Interestingly, however, no significant relationships emerged among these variables in the current study. Yet associations among BMI, SAD, and fruit and vegetable intake are plausible because fruits and vegetables are low in fat and energy density and replacing high-fat, energy-dense foods with fruits and vegetables may decrease caloric intake and thus, lower body weight. We may have been able to detect significant relationships among these variables, as other studies have reported, with a larger sample size, and thus greater statistical power. Nevertheless, our study findings suggest that participants of all weight categories should be equally considered when marketing dietary initiatives to increase fruit and vegetable intake for cardiovascular health. Furthermore, the finding that an average BMI of 25.8 classified our young adult sample as overweight, and therefore at increased risk for several chronic diseases including CVD, supports the need for more effective strategies to promote heart-healthy dietary patterns in the young adult sector.

The results of the current study must be considered in light of the limitations. The small sample size and cross-sectional design limit the generalizability of the findings. Additionally, there are limitations to the self-report method of identifying fruit and vegetable intake via electronic FFQs because participant responses may not accurately reflect actual food intake levels.

In conclusion, this study generated new knowledge about heart-healthy dietary choices of young adults in a state that has a higher incidence of CVD than the national average. It highlights the need for nurses and other healthcare clinicians to promote current health initiatives to increase fruit and vegetable consumption to all patients, but particularly to young adults for whom CVD prevention is a significant goal. Furthermore, the findings indicate that innovative strategies to promote heart-healthy choices should be used for young adults of all genders, races, and educational levels. However, novel dietary interventions that consider the unique needs of younger adults from lower socioeconomic levels may lead to better outcomes. Future research should consider larger samples of young adults in other regions of the U.S. in order to elucidate the effects of geographic and socioeconomic factors on meeting the AHA fruit and vegetable recommendations. By designing and implementing strategies to more effectively promote the AHA dietary guidelines, nurses may improve long-term cardiovascular health in the young adult population.

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